MM99.03 - Heat transfer coefficient between AA6082 and K190 at different pressure and temperature

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HEAT TRANSFER COEFFICIENT BETWEEN AA6082 AND K190 AT DIFFERENT PRESSURE AND TEMPERATURE

PRECIS4M TASK 47

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Measuring heat transfer coefficient

Introduction

The heat transfer coefficient between tool steel (K190) and an aluminium alloy (AA6082) has been examined by the steady state method, by use of the heat tester developed in task 47. A serie of experiments is made at different temperatures and different load. The specimens are all coated with zinksterate. The specimens are placed between the upper and lover die. The upper die is heated and the lower die is cooled, thereby a steady heat flow is establish. Figure 1 shows the temperature profile in the testing equipment. There is a constant temperature gradient in the upper and lower die. The temperature drops at the interface between dies and specimen due to the heat transfer coefficient. There is also a temperature drop in the specimen, due to the conductivity of the material.

The surface temperature (T_{s1} and T_{s2}) for the two dies are found by extrapolation of the temperature measurements in the dies. The heat flux density (q) is found:

$$q = \frac{k}{dt/ds} \quad [\mathrm{W/m^2}]$$

k: Conductivity of die   *dt/ds:* Temperature gradient in die

The temperature drop in specimen:

$$\Delta T_s = qh_s / k_s \quad [\mathrm{C°}]$$

h_s : Height of specimen

Temperature drop due to contact resistance:

$$\Delta T_{contact} = T_{s1} - T_{s2} - \Delta T_s \quad [\mathrm{C°}]$$

Heat transfer coefficient:

$$h = \frac{2q}{\Delta T_{contact}} \quad [\mathrm{kw/Km^2}]$$

The testing equipment is shown in figure 2. The heat tester can make a steady-state heat flow through a test specimen. The upper die can be heated too 300°C, and the lower die cooled down to 4°C. It is thereby possible to vary the interface temperature and the heat flux. The heat tester is positioned in a press to obtain different contact pressures. The pressure can be set higher than the flow stress of the specimen.

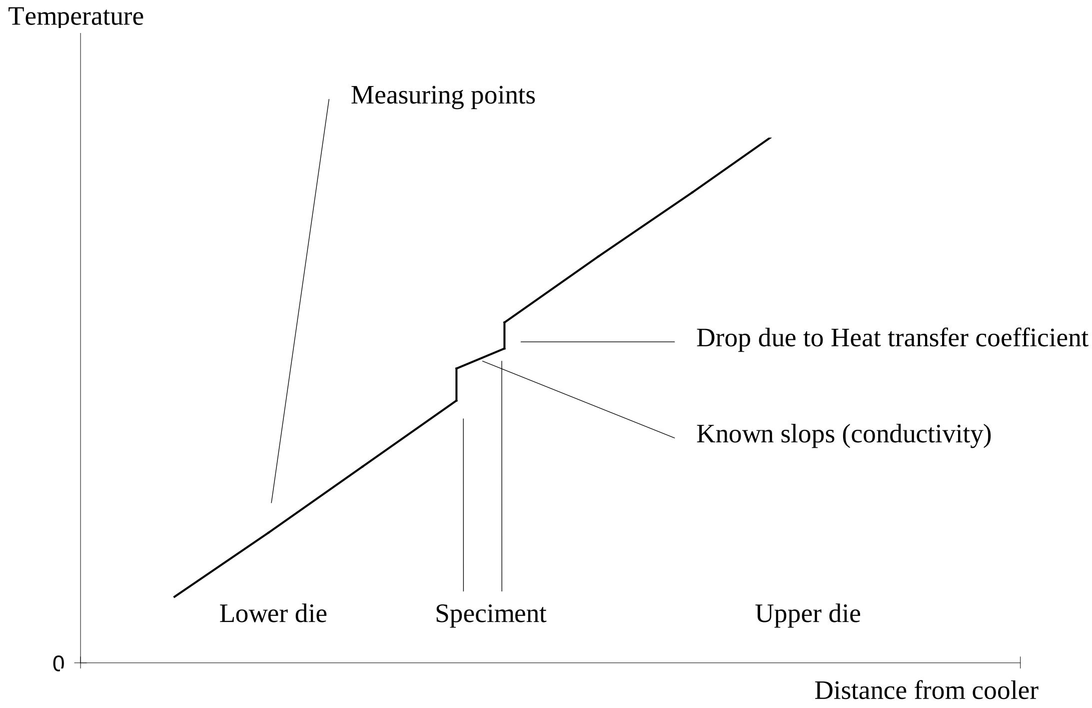

Figure 1 Temperature profile through the two dies and the specimen.

Figure 2 Testing equipment, open and without test specimen.

Experimental schedule
The experiments are made with three different loads and at three different temperatures. Two different loads without deforming the aluminium and one load above the flow stress, where the specimen is deformed with an equivalent strain of $\varepsilon = 0.23$. The specimens for the tests have the following dimensions:

Testing without deformation:
Ø: 18 mm   h: 2 mm

Testing with deformation:
Ø:16 mm   h: 3 mm

When testing with deformation is carried out, the specimen is deformed until its diameter expands to 18 mm, which is the same as the punch. This require a load of approximately 5.7 tons. Then the load is kept constant until a steady state heat flow is obtained, which takes about 1 hour.

The temperature at the interface is almost the average of the main heater temperature at the upper punch and the coolers temperature at the lower punch. The following corresponding temperatures at the heaters, coolers and interfaces are used for the experiments.

Main heater	Upper compensation heater	Lower compensation heater	Inner cooler	Outer cooler	Interface temperature
150 °C	+10 °C	+10 °C	7 °C	7 °C	**65 °C**
220 °C	+10 °C	+10 °C	30 °C	30 °C	**110 °C**
285 °C	+10 °C	+10 °C	45 °C	45 °C	**150 °C**

Figure 3

The three different loads are as follows.

Low: The pressure is obtained by the weight of the testing equipment (250N).
Surfaces pressure: $1 N/mm^2$

Medium The specimen is loaded with 2 tons
Surfaces pressure: $80 N/mm^2$

High The specimen is loaded with 5.7 tons
Surfaces pressure: $220 N/mm^2$

Results
The 9 experiments and the estimated heat transfer coefficients are shown in following figure:

Pressure / Temperature	$1 N/mm^2$	$80\ N/mm^2$	$220\ N/mm^2$
65°C	$4\ kW/Km^2$	$30\ kW/Km^2$	$114\ kW/Km^2$
110°C	$6\ kW/Km^2$	$34\ kW/Km^2$	$66\ kW/Km^2$
150°C	$3\ kW/Km^2$	$45\ kW/Km^2$	$315\ kW/Km^2$

Figure 4

From the results, it can be seen that the heat transfer coefficient grows with increasing surface pressure. When the pressure becomes so high that the material flows, the temperature difference between the two punch is less than 1°C. Approximately ½°C due to the conductivity of the test specimen. The heat resistance in the interface causes the rest. The surface temperature is found by extrapolating the temperature gradient. This gives an uncertainty at the surface temperature not less than $^1/_4$ degree. When the uncertainty is close to the same value as the measured temperature difference, the determined heat transfer coefficient is not so reliable. This is the reason why the measured heat transfer coefficient for high loads varies form 66 too 315 kW/Km^2.

At medium load the temperature has an influence on the heat transfer coefficient. When the temperature raises the lubrication become softer, and better thermal contact is establish. Figure 5 shows the relation between pressure temperature and heat transfer coefficient. The heat transfer coefficient for high loads are all given the value of 66 kW/Km^2.

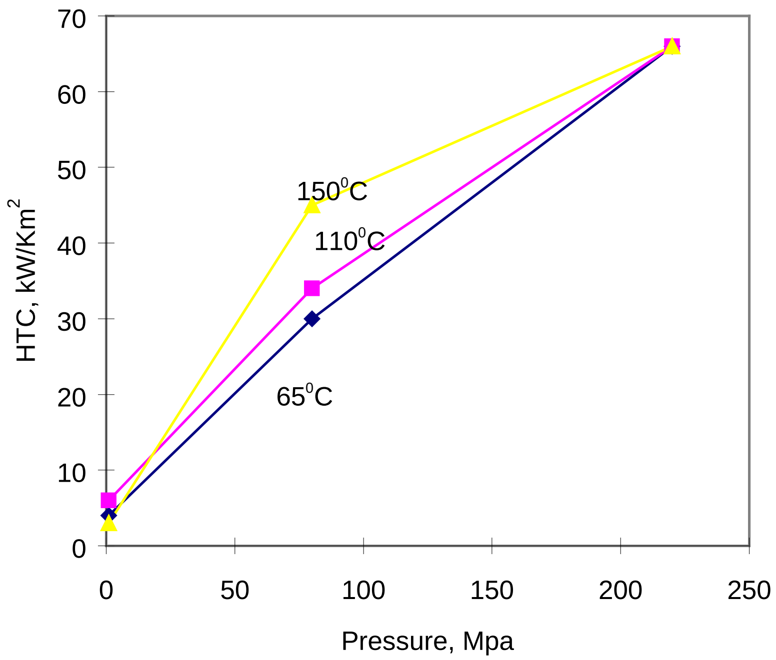

Figure 5 Heat transfer coefficient as function of pressure and temperature.